COMPUTER BASED PROGRAMMED LEARNING

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COMPUTER-BASED
PROGRAMMED LEARNING

By

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PREFACE

The subject of computer-assisted programmed learning was inspired by my interest in the learning process. Having attended public, private, and military schools and having taught in secondary schools for two years, I felt a need to evaluate some of the new concepts emerging in the field of education.

Progressive societies are motivated by the philosophy that there is a better way. To be truly progressive, our educational and training institutions need to be receptive to new ideas in order to find the better way. Computer technology is producing a major revolution in the business and military communities, and I feel that the educational field could share in this revolution if it can adapt itself to the potential inherent in the computer.

One learning concept that is structured for possible utilization with an electronic computer is that of programmed learning. Programmed learning has already been introduced into the educational field at nearly all levels. The medium used for information transmittal is usually a small, manually operated machine; although the use of a machine is not a necessity. Use of a computer as the controlling unit for a sequence of programmed material seems to be within the range of a modern computer's capabilities. The purpose of this paper is to explore the developments in the areas of programmed

learning and computer technology and to evaluate some recent experiments in computer-based programmed learning.

I would like to thank Dr. Glenn L. Bryan of the Psychological Research Branch of the Office of Naval Research for his interest in providing insight into this field of computer-based programmed learning. Dr. Bryan made his extensive library available to me to explore the recent writings in the field.

I would also like to thank Dr. Karl E. Stromsem for his patient guidance in the technical preparation of this paper.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

CHAPTER I

THE IMPETUS FOR EDUCATIONAL CHANGE

The art of "programmed learning" emphasizes some very practical learning concepts. Course material is analyzed and presented in small items, each containing a single idea or concept. A question is usually asked at each step to solicit a response from the student. The student must participate actively in every step of the course presentation. Each step is designed so that the student must fill in a blank or answer a question correctly in order to proceed to the next item. This active participation has led some people to refer to this type of instruction as "self instruction." Each small step helps build a framework of knowledge in which more difficult course material can be properly understood. The framework items are repeated or "reinforced" as the student proceeds through the course of instruction.

The media through which the course material is presented varies considerably. Some of these modes are the human instructor, programmed textbooks, manually operated teaching machines, and automatic teaching machines. When each student participates actively in each step of the program, it seems desirable to let him progress at his own rate. Unless there is an instructor for each student, the media of programmed textbooks or teaching machines have to be used.

In order to progress to the end of the lesson the student must answer each question correctly. In answering the question,

the student is constantly informed whether his response is right or wrong. Immediate confirmation does not allow the student to progress to difficult material without first having mastered the fundamentals.

Historical Development

The basic principles involved in programmed learning are not new, nor have they been misunderstood in the past. In fact the objective of programmed learning is embodied in the ancient art of tutoring. In tutoring, the instructor plans his presentation according to the needs and the demonstrated ability of the student. Under the tutoring system each response of the student is analyzed. Progression to the next step or level is carefully controlled so as to ensure proper understanding.

As education became available to the masses, the tutoring style of teaching gave way to the classroom method. In modern times, in our large secondary schools and colleges, it is not uncommon to find large lecture type courses with several hundred students in attendance. Little individual attention is given in this lecture type atmosphere. After reaping the fruits of this minimal type of education for many years, educators began looking into the past to compare the results of mass education with that of tutoring. Individual differences have now been given much attention. A separate discipline now exists in the field of psychology to explore further into the realm of differential behavior.

One of the early writers in the field of mechanized teaching was Sidney L. Pressey.[1] He worked extensively developing a number of small (typewriter size), manually operated teaching mechanisms. In a paper written in 1926, Dr. Pressey describes the operation of a small apparatus which would automatically give and score a test or teach informational and drill material more efficiently, in certain respects, than a human being. These machines were primarily intended to relieve the load on the teacher and to save considerable sums of money that was being expended on test forms and drill materials that could be used only once.[2]

In a paper written in 1932, Dr. Pressey reports about a device he had constructed which would score tests and tabulate the results be item.[3] In this paper he emphasized the following points: (1) There would be great savings of material and labor by using these devices; (2) Tests could be scored and results tabulated rapidly and automatically; (3) The apparatus could teach as well as test; and (4) There would be a possibility of close control, by machine, of important features of the learning process. Pressey describes his research as barely introductory, and he offered two predictions for the field of

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[1] S. L. Pressey, "A Simple Apparatus Which Gives Tests and Scores - and Teaches," Teaching Machines and Programmed Learning, ed. A. A. Lumsdaine and Robert Glaser (Washington: National Education Association of the United States, 1960), pp. 35-41.

[2] Ibid., pp. 35-41.

[3] S. L. Pressey, "A Third and Fourth Contribution Toward The Coming 'Industrial Revolution' in Education," Ibid., pp. 47-51.

education. He announced that education in America was still in the handicraft stage, and that we needed to use production methods to institute a needed industrial revolution in education. He pointed out the close relationship of change in a technology with the development of new instruments of research. He prophesied sweeping research advances in the fields of education and social sciences by the incorporation of new instruments and materials for research.[1]

The American public and its educational system did not seem ready for a breakthrough in educational technology. This lack of response from the public was probably due to the fact that there was no pressure being applied to make better use of the human resource. Development of natural resources, industrial production, and agricultural production were emphasized. American ingenuity was focused in these areas almost exclusively. Educational methods progressed during the war years, but not nearly as rapidly as methods in industry and technology.

During the post-war years television penetrated into almost every home, and its use in educational institutions became widespread. By the mid-fifties, though, it became evident that television was just another visual aid that could be used to provide variety and some depth in an educational program - it was not felt to be the answer to individuality in learning. Something was still lacking in our educational system. Individual differences were not being taken into consideration any more than they were in the

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[1] _Ibid._, pp. 47-51.

past. The only changes that had taken place were refinements in classroom facilities and some curriculum reconstruction. These changes did not alter, to any extent, the relationship between teacher and student. The relationship that existed then and exists today in the majority of our educational institutions is conceptualize in Figure 1, page 6.

In 1954, Dr. F. B. Skinner, a research psycholigist at Harvard, reported some of his findings that were to alter the traditional teacher-student relationship.[1] In his 1954 paper, Dr. Skinner describes two important advancements in the study of human behavior in the field of learning. The first was the law of effect. Taken seriously, effects had been caused to take place under optimal conditions producing changes called learning. These effects, or contingencies of reinforcement, were used to control the behavior of various laboratory animals. Very complex performances could be elicited by proper sequence of the reinforcement. It was demonstrated that an obvious change in behavior (learning) could be caused by a single reinforcement. The second advance was in the technique of maintaining the strenth of a certain behavior pattern for long periods of time through proper reinforcement.

To show the relationship between these experiments and the classroom situation, Dr. Skinner made some careful studies of arithmetic instruction on the grade school level. His conclusions were of a nature to alarm those involved in the

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[1]B. F. Skinner, "The Science of Learning and the Art of Teaching," Ibid., pp. 99-113.

[illegible]

[illegible] Figure I, page 8.

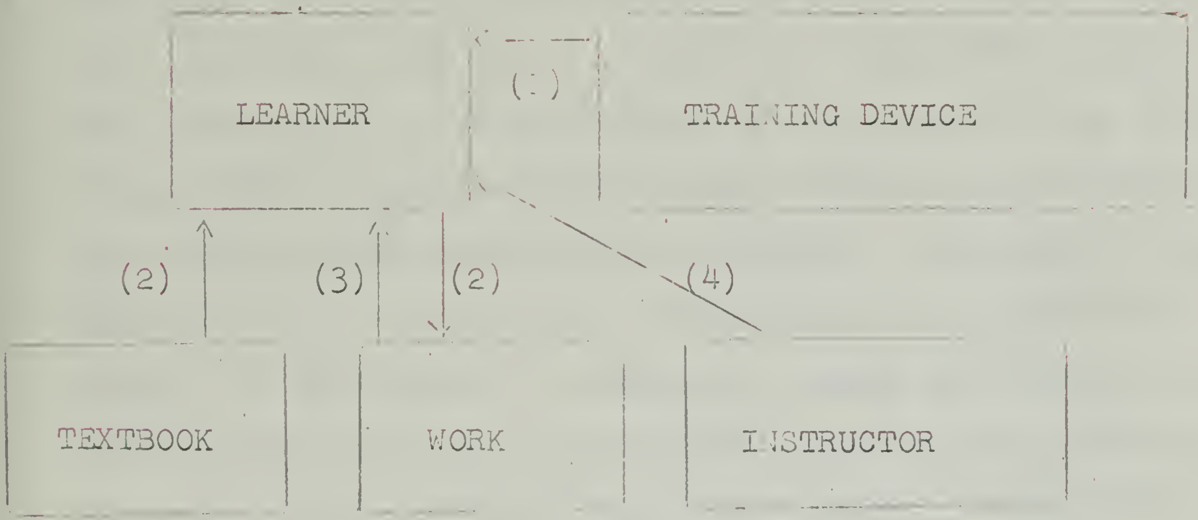
[illegible]

[illegible]

[illegible]

FIGURE 1

MAN-MAN RELATIONSHIP (GENERAL CASE)[a]



1. Human instructor instructs learner, perhaps using a training device such as a chalkboard or chart to communicate.

2. Learner uses instruction to conceptualize answer or solve problem; may use textbook, manual or similar device.

3. Learner returns instruction; may raise questions or solve problem.

4. Learner may be questioned or tested by instructor.[b]

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[a]L. C. Silvern, "Teaching Machines and Programmed Learning in Data Processing," Data Processing Yearbook, (New York: American Data Processing, Inc., 1963), p. 84.

[b]The time that elapses between the solution of the problem and the verification and testing by the teacher may be as much as twenty-four hours. The value of the exercise may be lost during this extended period of time.

education process. Dr. Skinner estimated that a complete level of arithmetic learning (one year) should be comprised of approximately fifty-thousand contingencies. These contingencies were provided in the traditional teaching process every time the teacher validated a student's answer to a problem as right or wrong. Of course, some results on problem solving had to wait for twenty-four hours or more for teacher resolution. With thirty-five or more students in one class one can see very quickly that in one year each student would have difficulty approaching fifty-thousand contingencies. The period of time between problem solving and resolution by the teacher was enough, in some cases, to completely negate the benefits of problem solving drill. Dr. Skinner's conclusions were that mechanical or electrical devices were needed. The teacher, used as a reinforcing mechanism, was far out of date. He points out that time with the teaching device would be about fifteen or twenty minutes a day to achieve the desired contingencies.[1]

In an article published in 1958, Dr. Skinner devotes much time in presenting his arguments for teaching devices.[2] He discusses in detail the involvements in program construction. Although recognition of these advances in educational technology will cause improvements in textbooks, films, and teaching methods, Dr. Skinner still feels that the desired individual

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[1] Ibid., pp. 99-113.

[2] B. F. Skinner, "Teaching Machine," Ibid., pp. 137-158.

attention can come only through the use of some mechanical or electrical teaching device.

With Skinner's contributions to the field of education and training technology, there is now a solid educational theory to couple with advanced research instruments. Dr. Glenn L. Bryan, a research psychologist with the Office of Naval Research, attributes the increased interest in educational technology to the following developments: "(1) The population was expanding rapidly, overtaking the training facilities, (2) Technology was increasing at a gallop, automation was the watchword, (3) The amounts of information to be learned were increasing explosively."[1]

Criteria for use of Teaching Machines

The previous teacher-student relationship shown in Figure 1, page 6, has been altered because of Skinner's findings and the advances made recently in programmed learning. The proposed relationship is conceptualized in Figure 2, page 9. Figure 2 shows the instructor as a machine rather than a human being. Leonard C. Silvern has proposed a list of criteria for the use of machines in programmed learning that may be applicable to most training situations:

1. Instruction is provided without the presence of an instructor.
2. The student learns at his own rate.
3. The student receives immediate knowledge of his progress through feedback.

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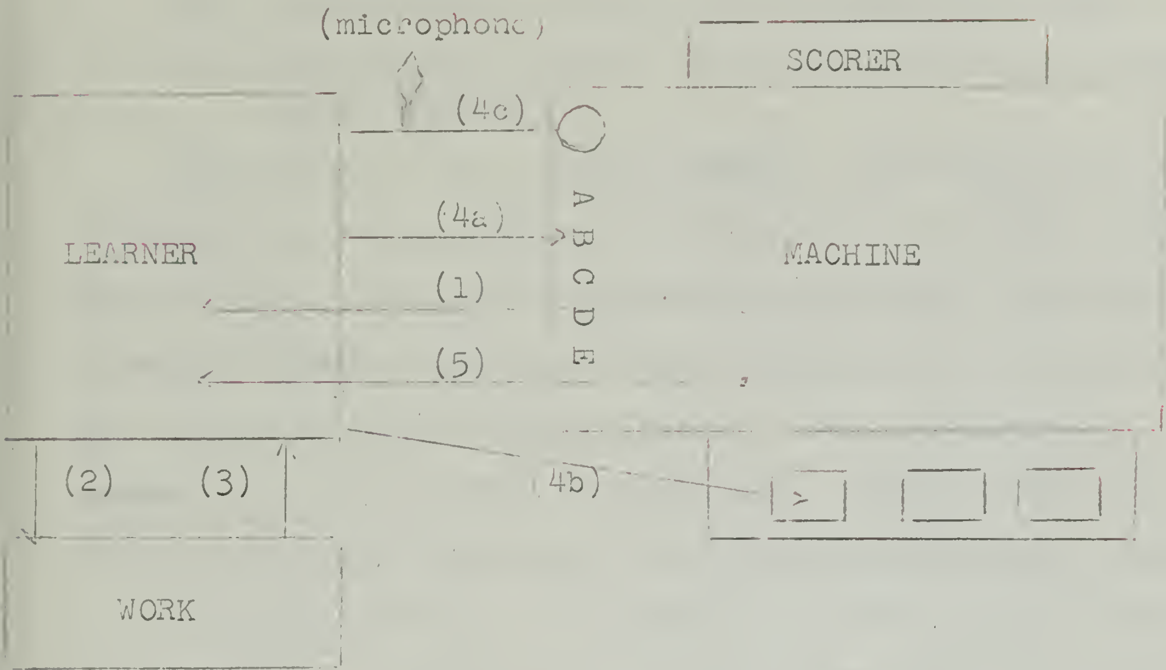
[1] G. L. Bryan, "The Unrealized Potential of Teaching Machines," an unpublished paper dated 10 March 1964, p. 1.

FIGURE 2

GENERAL PURPOSE TEACHING MACHINE[a]



1. Machine instructs learner visually and aurally, then provides question or problem.

2. Learner uses instruction to conceptualize answer or solve problem.

3. Learner decides upon answer or solution.

4. Learner informs machine by:
   a. Multiple choice
   b. Written completion
   c. Oral completion

5. Machine verfies or has learner verify response and feeds this back to learner. Learner may repeat, branch or go on to next incremental instruction depending upon curriculum design.

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[a]L. C. Silvern, "Teaching Machines and Programmed Learning in Data Processing," Data Processing Yearbook, (New York: American Data Processing, Inc., 1963), p. 54.

4. There is a participation, overt interaction or two-way communication, between learner and machine or program.

5. The sequence of the lesson is carefully controlled and consistent.

6. Reinforcement is used to strengthen learning.

7. The teaching machine mechanism shapes and controls human behavior.[1]

The heart of the machine-student relationship can be recognized as being textual analysis and educational program construction. Any learning experience through programmed learning depends largely upon the validity and reliability of the constructed educational program. Many problems and unknowns are being faced as educators, business executives, and military training directors seek to utilize this new concept of programmed learning. An extensive study of the principles and problems of programming is called for prior to facing the problem of machine selection.

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[1] Ibid., p. 86.

CHAPTER II

CONCEPTS OF EDUCATIONAL PROGRAMMING

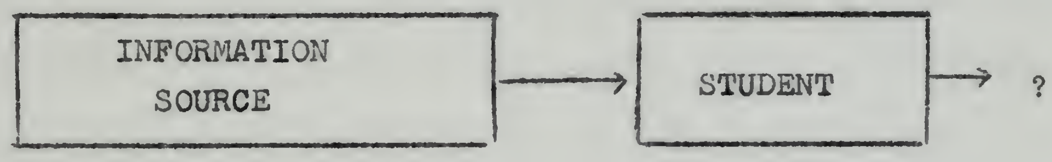
Even a skilled teacher experiences difficulty presenting course content through the use of a poorly constructed textbook. It takes much time for clarification by the instructor to make up for the deficiencies of the text. Most individuals have experienced a situation in their educational experience when a teacher has had to say; "Now what the author means by this is...", "This material was alright ten years ago but in the light of recent developments...", or "This example is very misleading and should be explained in this way."

Machines are now being considered that will replace human instructors in many training areas. Machines available today are still severely restricted in comparison with their human counterparts, as they cannot respond candidly if the course material is poorly constructed and confusing. The machine does exactly what it is told to do by the technician in meeting various pre-determined situations. With this restriction on the machine, it becomes paramount that the program be constructed so as to contain the essentials for understanding. It must be sequentially presented in a fashion that each acquired bit of information builds upon an established foundation. It can be concluded very easily that a poorly constructed program, presented to a student through machines that are unable to clarify and explain, will have detrimental

results. Almost every advantage that teaching machines and programmed materials have over conventional teaching stems from the program construction.

Programmed instruction's basic purpose is to close the loop in the process of information transmittal. This is very simply illustrated in Figure 3.

FIGURE 3[a]



(a) The open system merely transmits information.

(b) The closed system can ensure that it is received and understood.

[a]Max Sime, "The Elements of a Teaching System," Teaching Machines and Programming, ed. K. Austwick (New York: Macmillan Co., 1964), p. 117.

Persons familiar with conventional teaching will say, and rightly so, that a closed system already exists in the question and answer sessions between teacher and student and in conventional testing. The essential difference lies in the time taken for confirmation and in the participation of each student in every step.

Programming Theory

Two major schools of thought have developed concerning program construction. The first to arise was the school headed by B. F. Skinner. Skinner's concepts proposed a linear program with a constructed response. The second school to develop was that of branching with a multiple-choice response. This school can probably be referred to as the Crowder school, although Pressey used multiple-choice items in his experiments in 1926.

The terms linear, constructed response, branching, and multiple-choice response should be understood before proceeding into any theoretical discussion. Linear means that a student proceeds along one path dealing with each item until he reaches a desired level or goal. A constructed response is one which the student must recall when confronted by the proper stimulus. Branching is the opportunity for a student to proceed along any number of paths to reach a desired level or goal. A multiple-choice response is one that is chosen from any number of given plausible answers.

Skinner's concepts are derived from two beliefs.[1] First, he believes that recall is more efficient than recognition in the learning process. Second, he believes that presenting a student with a choice of alternatives may cause him to learn the wrong answer. In order to avoid the construction of wrong

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[1]David Cram, Explaining "Teaching Machines" and Programming (San Francisco: Fearon Publishers, 1961), pp. 18-23.

answers, Skinner feels that each step (frame or item) must be short enough so that students can answer correctly. With short steps the student is responding frequently and is thereby aided in learning. It is also felt that the student learns better when he is successful, as he would be in dealing with short steps that are constructed to minimize errors.

Norman A. Crowder, manager of the Training Systems Department at Western Design in California, has been the champion of the branching concept and the use of multiple-choice questions in the single step or frame.[1] The assumption in branching is that the wrong response does not necessarily hinder the learning of the correct response. The response is used mainly to guide the student through the program. Each response tests the success of the latest communication to the student and lets the program know where to take him next. It is Crowder's contention that the overt response is a measurer rather than a fixer of learning. Instead of being detrimental the wrong response can be used to uncover weaknesses in the student's thinking.

Crowder supports his use of multiple-choice questions by suggesting the different ways that they can be used.[2] They can be used to: (1) determine whether the student has learned the material just presented, (2) select appropriate

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[1]Ibid., pp. 39-41.

[2]Norman A. Crowder, "Intrinsic and Extrinsic Programming," Programmed Learning and Computer-Based Instruction, ed. John E. Coulson (New York: John Wiley and Sons, Inc., 1962), pp. 59-60.

corrective material if necessary, (3) provide practice, (4) keep the student actively working with the material, and (5) motivate if the question is answered correctly. Besides these purposes a difficult question or a series of difficult questions can be used to determine whether or not a student may skip a block of items. In sharp contrast to Skinner's concepts of short, errorless steps, Crowder feels that some of the major branching questions should be difficult enough to have ninety percent of the students select the wrong answer. On routine steps the difficulty should allow no more than fifteen percent wrong selections.

Dr. Pressey's support of the use of multiple-choice questions comes from two laws - the law of frequency and the law of recency. The law of frequency states that the right response tends to be the most frequent as it is the only response that will allow the student to proceed in the program. The law of recency states that the correct answer is always the last one made, so it is more likely to be remembered.[1]

In comparing the two schools we find that they are alike in many ways and can be mixed in the construction of some programs. The objectives of the two theories are the same. They both seek to raise a student's level of knowledge and understanding to a pre-determined level. The two theories agree that immediate confirmation or reinforcement is necessary after each step. Both of the theories utilize the construction of incremental steps to be used in achieving the desired goal.

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[1]Cram, op. cit., p. 34.

Until many programs have been constructed, used, and evaluated, the validity of the two theories will remain undecided. Many educational and non-educational institutions are working rapidly to bring some concept of standardization to this new approach to learning.

Program Construction

Lloyd E. Homme and Robert Glaser have suggested two systems or set of rules to govern the construction of programs.[1] These two systems are: (1) a system for analyzing knowledge to be included in the program and (2) a system for frame writing to impart this knowledge to the student.

Frame writing will be considered here as it is the responsibility of the expert in his field to determine what knowledge is to be included in the program. Homme and Glaser have developed the "Ruleg" system of programming which seems to embody the intent of most programmers. Very simply stated, the word ruleg is broken into two parts: (1) RU stands for rule or principle, and (2) EG stands for examples and illustrations. The idea is to state in one frame the rule and possibly an example, and then in succeding frames give illustrations and examples that give the full expanse of the principle. The number of examples that give depth to the principle can be related directly to the intended coverage of the course material.[2]

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[1]Lloyd E. Homme and Robert Glaser, "Problems in Programming Verbal Learning Sequences," Lumsdaine and Glaser, op. cit., p. 487.

[2]Ibid., pp. 486-496.

There are many books now in print that treat these programming steps in great detail, and they can be very useful to an instructor in industry, the military, or public schools even though he does not intend to use programmed materials. The training in sequential presentation can be most helpful for the instructor now utilizing traditional training methods.

Item Length

Although the theory of programming accepted by the programmer will have some bearing on the item length, there are considerations that have to be made by a programmer. Edward B. Fry has suggested that some considerations to be made by a programmer are, the control of the size of the frame, its precise content, the response it is intended to evoke, its place in the total program, the amount of prompting that ought to be included, the readability of the material and other related influences.[1] In controlling the size of the frame the programmer can approach the problem by controlling the number of words or sentences, by limiting the number of ideas contained in one frame, or by adjusting the length of time needed to compute and answer.

Most programmed materials in use today approach the problem of item sized by using very short steps with one idea included in each frame. This approach has much to recommend it, as the student is rewarded (the answer is confirmed) very frequently. The small step provides little room for confusion in comparison to a page in a textbook with two or three ideas

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[1]Edward B. Fry, Teaching Machines and Programmed Instruction (New York: McGraw-Hill Book Co., Inc., 1963), pp. 130-131

contained on it, and the student is required to participate actively in order to progress.

The use of multiple-choice questions and explanations as to why answers were right or wrong tends to require items of greater length. Lumsdaine has commented on this type of approach by saying that most of the learning comes from reading or being lectured to by the item. There is also a tendency for the item to be more difficult to comprehend, bringing forth more errors from the students. The error required an explanation as being the improper choice and will probably lead to some corrective subroutine. Lumsdaine prefers the use of small steps in order to minimize error and confusion.[1]

Prompting

One of the basic considerations in programming is to evoke the proper response. In most cases the proper response is evoked by some type of prompt within the item or in previous items. The prompt (or cue) is used effectively in any method of item construction. Dr. Skinner's hypothesis, simply stated, is that maximum prompting early in learning leading to minimal prompting in the latter stages produces optimal learning.[2] This concept of prompting is the most accepted concept and is the basis for most of the use of

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[1] A. A. Lumsdaine, "Some differences in Approach to the Programming of Instruction," Programmed Learning, ed. Jerome P. Lysaught (Ann Arbor, Michigan: The Foundation For Research on Human Behavior, 1961), pp. 43-44.

[2] Robert E. Silverman, Automated Teaching: A Review of Theory and Research Technical Report: NAVTRADEVCEN 507-2 (Port Washington, New York: U. S. Naval Training Device Center, 1960), p. 4.

prompts in programmed materials available today.

There are many variations that can be used in constructing the prompt; however, they usually fall into two broad categories: the formal prompt and the thematic prompt.

An example of a formal prompt would be the inclusion of the desired word somewhere in the item itself. Another example would be the use of the first two or three letters of the desired word. Pictures can be used to evoke the right response.

The formal prompt would probably be used in the early part of the course and would be "vanished" as the student progresses. It is desired that the student obtain and retain the principles of the course presented. It is this desire that leads to the use of the thematic prompt. As the formal prompt is gradually vanished it is hoped that the student will begin to respond to thematic prompts that are given in the form of the statement of a principle or rule.

Under the guidance of basic theory, the programmer is usually free to utilize any of his creativity in construction of the prompt. There are a few studies that have been made to determine the type of prompt to be used; however, there is no strict procedure that has yet been developed in this area.

Response Mode

The theoretical considerations of the response mode (constructed / multiple-choice) have already been presented. The concepts should be visualized in order to clarify the theories previously presented. Figure 4 is a conceptual view of a linear presentation.

FIGURE 4

$$A \longrightarrow B \longrightarrow C \longrightarrow D$$

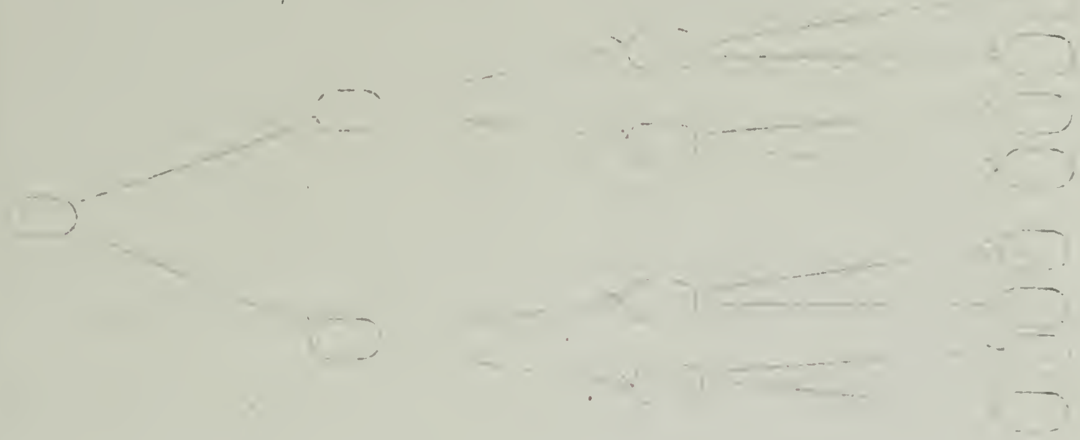
The student looks at item A and responds by constructing an answer. After confirmation of his answer he progresses to item B. The student must respond to each item in order to progress to the end of the sequence.

Branching concepts are designed to make allowances for individual differences and are therefore more complex in their design. Figure 5, page 21, shows three examples of Crowder's branching methods. Example one shows three steps with two choices at each step. One student may never read the item read by another student who made a different choice at one step in the program. The second example is a simple branching program that sends the student to an item off the main linear path for explanation of his wrong choice. The remedial item then sends the student back to the original "main line" items to make another choice. The third example is a complex remedial sequence that requires a correct answer to A' in order to proceed to the next item on the main line. This type of branching is adaptable to individual differences where a student's previous knowledge and training are considered.

There seems to be no substantial reason why constructed responses should be used exclusively with linear programming methods or multiple-choice responses exclusively with branching methods. Future methods may be eclectic and use both to the advantage of the course material and efficiency of

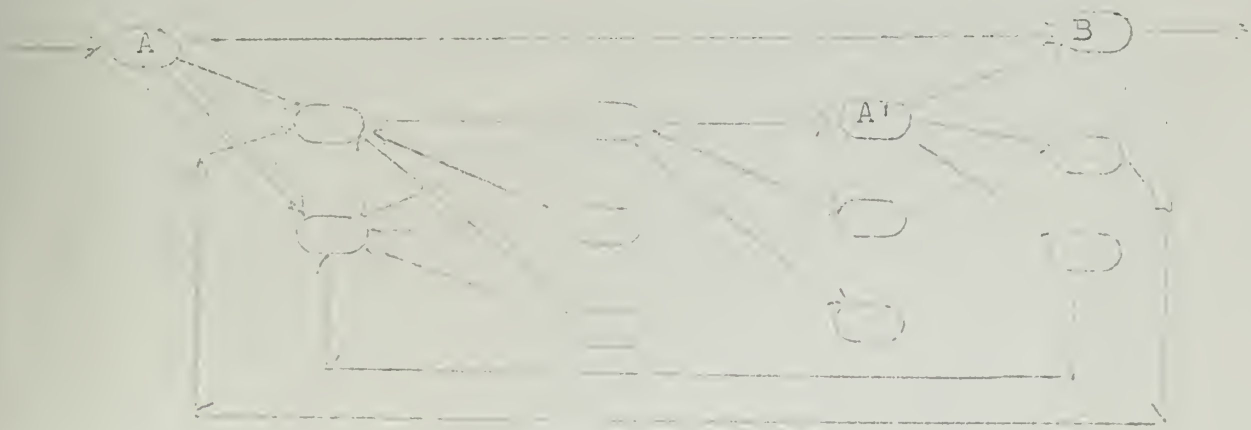
FIGURE 5

CROWDER'S BRANCHING CONCEPTS[a]



Branching program for scrambled book: three steps with two choices at each step.

Simplified branching program for scrambled book.



Branching program with remedial sequence.

[a]N. A. Crowder, "Intrinsic and Extrinsic Programming," Programmed Learning and Computer-Based Instruction, ed. John E. Coulson (New York: John Wiley and Sons, Inc., 1962), p. 62.

learning.

In Figure 6, page 22, Max Sime presents a conceptual view of this possible combination of methods. Example one is the common multiple-choice method of branching. The second example is a constructed response sequence for remedial work. Example three shows a possible combination of the two response modes. It is of interest to note that the main sequence frames constitute a linear program if correct responses are recorded on each item. In Figure 7, page 24, Sime shows us a conceptual view of the decision logic involved in the branching method.

Because of the complexity of branching sequences this method is more adaptable to computer control. Linear programs can be controlled by computers; however, linear type programs can also be presented very effectively in small, manually operated machines or textbook arrangements. The whole concept of adapting the presentation to the desires and differences of the individual has brought serious consideration of using computers as the medium in which to exploit the benefits of individual development.

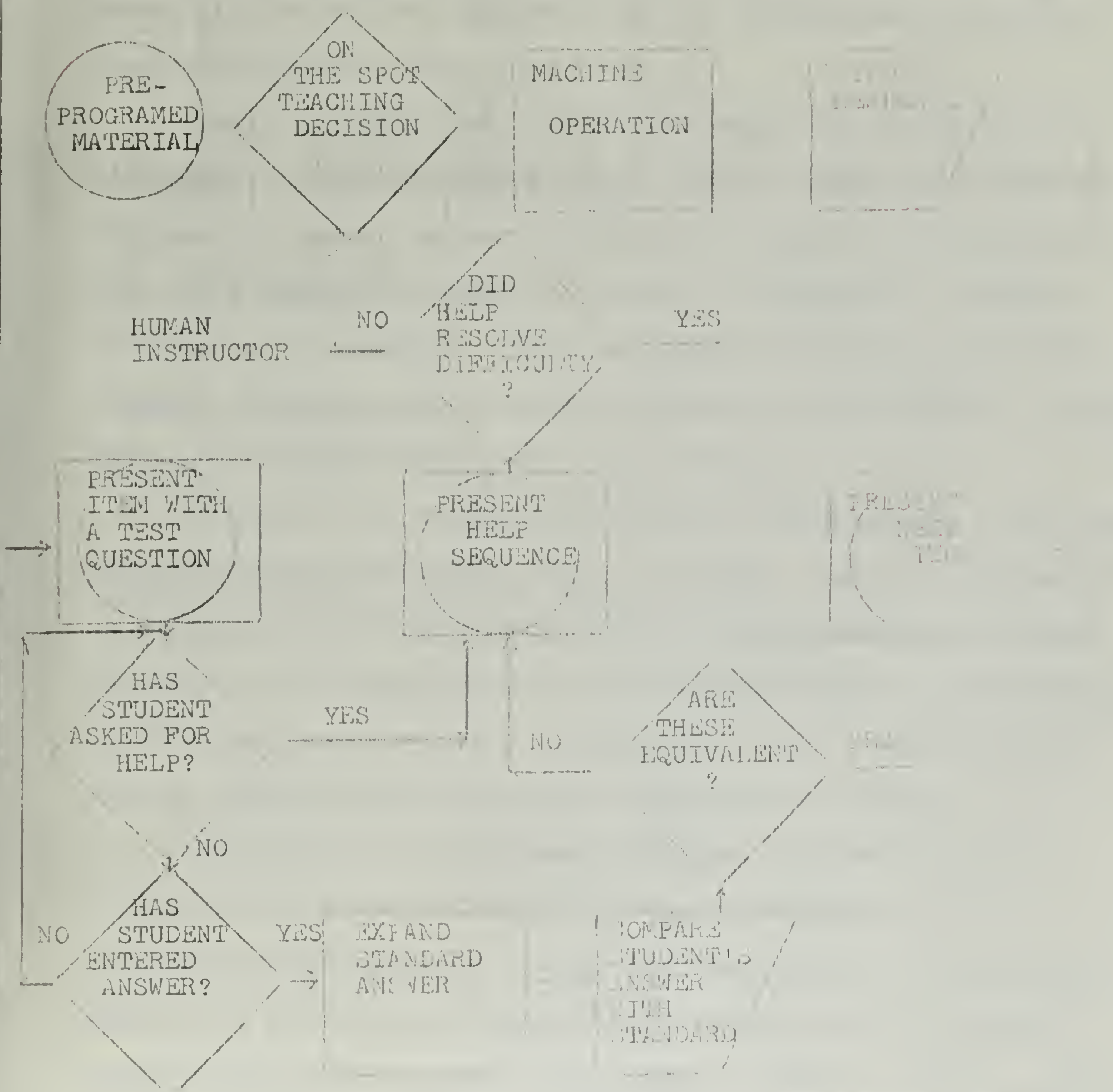
<u>Other Considerations</u>

Some other factors that influence the effectiveness of programmed instruction are rate of progression, interest level of the material, rewards, and cheating.

The rate of progression can be controlled to any desired degree in an automatic or computer controlled program. There are basically two points of view: (1) Students should progress

FIGURE 7

A POSSIBLE DECISION LOGIC
FOR A SIMPLE SKIP-BRANCHING SYSTEM[a]



[a]Max [illegible], 'The Elements of a Teaching System,' Teaching Machines and [illegible], ed. [illegible] (New York: Macmillan Co., [illegible]) [illegible]

at their own desired rate, and (2) The rate should be controlled by the machine. Proponents of the concepts of individualization of the program would argue that the optimum learning would come from student control of rate. The opposite view would be that pressure from a set rate would increase the participation of the student with the program and make the learning process a more rapid one.

It is conceded that programmed materials can be just as boring to read through as some books. Making the subject interesting should be one of the objectives of the programmer. Fry has suggested a number of things to consider in making material more readable. Some of these are clarity, size of letters, writing style, format, types of illustrations, variety, length of single lesson, and use of color.[1]

Rewards from programmed material are generally considered as the knowledge of being right or wrong. Some consideration is being given to the method for disclosing this information. Examples of this are green or red lights, written confirmation, audible confirmation, or a combination. Not enough is known now to prescribe any particular method over another.

Cheating is a widespread practice in traditional instruction and can be a factor in the effectiveness of programmed instruction. It has not been proven conclusively that it is definitely a detrimental factor in the learning process when dealing with programmed materials; however, many small, manually controlled machines and all computer controlled machines can be made to be cheatproof. If cheating can be

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[1]Fry, op. cit., pp 177-178.

proven to be detrimental in the learning process, the role of computer controlled teaching machines will be greatly enhanced. It is the opinion of most educational psychologists that cheating lessens the effectiveness of learning in most cases; however, this opinion should not be confused with the morality involved.

Contributions From Industry

Eastman Kodak Company is very interested in the field of programmed learning.[1] In their initial entry into the field they programmed a course in sensitometry with a supplemental course in logarithms for those whose backgrounds did not include this knowledge. The programmers were from the company staff. The company plans to program many courses in color photography, theory of photography, theory of black-and-white and color and other fields of knowledge that come from their research laboratories.

International Business Machines Corporation has been active in the research of programmed learning for many years.[2] Their initial focus was on programming rather than machines, as it was felt that the machine applications could be handled easily after the programming techniques had been thoroughly explored. They found that it took approximately two weeks for a programmer to write, revise, rewrite, and try out fifty frames. In testing a trial program, three criteria were explored: (1) the amount of time saved, (2) the achievement of the students,

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[1]James S. Bruce, "Using Programmed Instruction," Lysaught, op. cit., pp. 31-36.

[2]Walter J. McNamara and John L. Hughes, "IBM's Experience in Developing Programmed Instruction," Ibid., p. 53.

and (3) the reaction of the students to programmed instruction. The results of the experiments were considered favorable.

> To determine the comparability of the control and experimental groups, we have obtained the age, educational background, previous experience, and aptitude test scores of all students as part of our experimental control. Results obtained indicated that the experimental group which was presented the programmed instruction material in 11 hours achieved an average score of 95.7 on the achievement test compared to an average score of 86.2 for the control group which had 15 hours of lecture. Thus the experimental group which covered the programmed instruction material in 11 hours instead of 15 for the regular lecture method - a saving in time of 27% - scored 9.5 points higher, a gain of 11%. In addition, on the aptitude questionnaire administered to the experimental group, the replies of the students were highly favorable to programmed instruction. Of the total group, 87% liked programmed instruction somewhat or much more than the regular classroom method, and 92% would prefer or strongly prefer to see it used in future IBM courses. The students thus generally appeared to accept programmed instruction and recognize its advantages.[1]

Attention will now be focused on the more exciting and dramatic phase - the application of computer technology to programmed instruction. The technology associated with information retrieval systems is bringing about a revolution within our business world, and the effects will soon be felt in almost every area of our society. The term information is common to both the business and educational worlds, and the applications of the technology can be related to both worlds.

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[1] Ibid., pp. 56-57

CHAPTER III

COMPUTER APPLICATIONS IN EDUCATION

Applications of computer technology seem to be limited only by the creativity of the human mind. With this statement as a basic assumption it should be the task of the educational technologist to state as thoroughly as possible his desires as to the structure of the computer system to be utilized for educational development and research. Adapting one's desires to the existing machinery available today would be an inadequate solution to the training problem.

In order to understand the technical capabilities of computer technology in relationship to educational goals, the following areas will be considered: (1) machine requirements, (2) computer capabilities, (3) input-output devices, and (4) recent experimental findings.

Machine Requirements

It is a recognized fact that the technology of computers is far ahead of the ability of organizations to adapt to the opportunities presented. This situation is most unfortunate, as the conceptualizing of an adequate criteria for computer utilization in education has not been forthcoming. The reality of the situation is that machine manufacturers and behavioral psychologists have been the first ones to develop any statements that would seek to govern and control the research attempts made in the training area. It would be a much more compatible situation if educators, military training experts,

and industrial training personnel were to set forth the criteria from within the realm of their own teaching experience.

An example of industrial development of machine requirements is the Eastman Kodak Company. In presenting its program on sensitometry and logarithms it also gave definite consideration to the machine aspect.[1] The specifications for the machine that were given to the design engineers by the training specialists were as follows: (1) The device must be able to present both sequential, constructed answer type materials and various types of non-sequential, search type programs; (2) It must be able to handle any number of inputs in a standard format, such as verbal items, graphic presentations, illustrations, charts and color materials; (3) The system should be miniaturized, if possible, by using microfilm; and (4) The machine must be produced as economically as possible.

James D. Finn, in a project for the National Education Association of the United States, conducted a survey of teaching machines (manual, electric, and computer-based) and programs that were available in 1962, or those that were in the developmental stages. To be included in the survey the machines had to meet five of the following basic functions:

<u>Basic Functions</u>

1. Used for individual instruction.
2. Contains and presents program content in steps.

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[1]Jerome P. Lysaught, "Exploring Programmed Training," Lysaught, <u>op. cit</u>., pp. 25-30.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

3. Provides a means whereby the student may respond to the program.

4. Provides the student with immediate information of some kind concerning his response that can act as a psychological reinforcer.

5. Presents the frames of the program individually.

6. Presents the program in a pre-determined sequence.

7. Is cheatproof.

Additional Functions

8. Discriminates correctness of response.

9. Automatically advances program.

10. Provides random access to program frames allowing for branching.

11. Memory function holds out frames on which error has been made for further presentation.

12. Records results.

13. Selects program items based on evaluation of previous responses.

14. Permits two-way communication between student and machine (typewriter - computer).

15. Stores complete programs and responses.[1]

Most computer-based machines are felt to be adequate to meet all of the requirements of the survey by Finn. Whether or not all of these functions are actually desirable for efficiency in learning will be discussed in the following chapter on teaching systems and organization.

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[1]James D Finn and Donald G. Perrin, Teaching Machines and Programmed Learning, 1962: A Survey of the Industry, A Report prepared for the Technological Development Project of the National Education Association of the United States (Washington, D. C.: National Education Association of the United States, 1962), p. 18.

Computer Capabilities

The connection between programmed learning and computers was a fairly easy one to construct as the ideal tutor-student relationship could feasible be made a computer-student relationship if certain computer qualities could be exploited. Some of these capabilities are speed, accuracy, internal memory, random access to external storage, buffering, and the ability to handle exceptions.

The computational speeds of computers today are so fast that one has a difficult time comprehending that speed. This computational speed is usually referred to in milliseconds (thousandths of a second), microseconds (millionths of a second), and nanoseconds (billionths of a second). To gain an appreciation for the advances made in computer speed it is interesting to contrast two machines. The work that a large twenty year old vacuum tube machine produced while functioning continually for eighteen years on scientific calculations could be duplicated in forty-five minutes on a solid-state computer manufactured today. This speed is related directly to the amount of information that can be processed. For educational uses speed could probably be associated with the number of student terminals that could be serviced with no appreciable delay in information processing. Of course speed would not be the only determining factor in the number of terminals that could be utilized; however, it could be a limiting factor taken by itself. The next few years should bring more advances in computer speeds that will be referred to as speeds of trillionths of a second.

Large businesses and missile guidance systems depend on the accuracy of the transformation of raw data into usable form. Any significant error in the computation of raw data could mean the inflation of a market or the pre-mature destruction of a missile on its way to a target. Many internal controls are being incorporated in the computers to seek out and correct errors in a program before they have detrimental results. Basically this accuracy concerns the program logic and not the content of the information. The computer cannot tell whether the programmer meant to say ball or bell, but it can tell if the programmer said it correctly in machine language. It is coming into the computer's range of abilities to distinguish whether or not the word should be ball or bell by its ability to compare this data with other stored data. This feature is significant for educational use as a student's answer could be evaluated by the computer to see if it measures up to the standard expected. The lack of ability of the computer to make fine distinctions in evaluating answers is one of the weaknesses that a computer has in comparison to a human tutor. A simple way to by-pass this weakness is to use a multiple-choice response rather than a constructed response in verbal learning situations.

The internal memory of the computer or the internal storage capacity of the computer determines the "size" of the machine. The evolution from vacuum tubes to core and thin film devices has given today's computers the ability to store many programs internally for simultaneous processing.

It is conceivable that programs controlling all of the courses offered at a particular training institution could be stored internally on two or three large computers. The pressure exerted by business users for more machine capacity will be beneficial for the educational user.

Using magnetic drums and magnetic discs as external storage, the computer has random access to a great amount of potentially useful information. One weakness of previous computers for educational use was the dependance upon magnetic tape for external storage. Tape does not provide for random access, and the opportunity of Soliciting related information from the computer in a problem solving situation was not possible. Of course, random access to 35mm slides could be accomplished; however, to be completely adaptable, the computer should be able to draw on a vast store of information that could not be economically pre-printed on 35mm slides. The slide projector would be a computer driven accessory and not part of the computer system as are discs and drums.

Data buffering promises more efficient utilization of the central processing unit. One student working with a computer could not utilize more than a very small percentage of the computer capacity. In order to utilize the computer for large numbers of students, a time-sharing plan had to be developed. In very simple terms the data buffer acts as a temporary storage device to control the input into the central processing unit. If one hundred students made some type of inquiry or response at the same time, this information would go to the Buffer to be stored temporarily as the machine worked

on each item separately. Operating in millionths of a second, it appears that each item is treated simultaneously. Harry D. Huskey, of the University of California, states that undue concern should not be shown over large memories or buffers. He mentions several research projects in progress to develop miniaturized components. He mentions research processes that may permit as many as 10^{12} elements per square inch and perhaps 10^5 layers in a cubic inch. To gain the significance of this advance, is to realize that in 1960 all of the books printed in the United States had a total of about 10^{14} characters in them.[1]

The ability to handle exceptions is an ability that the most recently developed computers have established. This one ability can have tremendous implications on the educational uses of the computer. This ability can be described very simply as the access to any information stored internally, in a buffer, or disc storage while the computer is involved in processing other data. IBM's 360 system incorporates features that allow telephone inquiries to be handled by the computer while the computer is busy working on other programs. The inquiry is answered by a print-out, visual or graphic display, or audibly through the telephone receiver.[2] This feature has great potential for educational use in formal

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[1]Harry D. Huskey, "Automatic Computers and Teaching Machines, Coulson, op. cit., p. 258

[2]International Business Machines Corporation, IBM System/360 System Summary, Report No. S360-00 Form A 22-6810-2 (White Plains, New York; International Business Machines Corporation, 1964), pp. 34-44.

programmed courses or in non-directed problem solving situations. An example of a non-directed problem solving situation would be a student who desired to prove a theorem or substantiate an opinion. He could solicit answers from the computer or submit formulas for computation in order to prove his theorem.

Input-Output Devices

Little has been said about input-out put devices used in conjunction with the central processing unit of the computer system. It is in this area that the most significant developments can be made to advance the techniques of computer-based programmed learning. Two areas will be examined - the information sources and the student terminals.

Standard input devices are magnetic tape, magnetic drums, magnetic discs, punched paper tape, and punched cards. Many of these input devices can be used simultaneously with modern computers. Much of the information can be obtained randomly from some of these input devices. Punched paper tape, punched cards, and magnetic tape have limited capabilities for educational applications. These devices serve business needs very well where straight line runs are used to update and alter sets of records. Educational uses that include student participation are not adaptable to a straight line computer run.

Magnetic drums and discs incorporate the random access features that are essential for a truly adaptable instructional device. A variety of graphic materials such as blueprints, illustrations, graphs, and product drawings can be transformed

into binary numbers and stored on drums or discs. This information can be transformed back into a visual display when the information is solicited.[1] Of course vast amounts of textbook material can be stored in the same way.

Two recent advances in the source data field have great promise for educational applications. These two advances are the videofile system and the mechanized library.

The videofile information retrieval system is a completely automated micro-filing system which stores documents on magnetic video tape. This system was first presented by the Ampex Corporation in August 1964. The system, as it exists, is custom engineered for a specific application. This application is to video tape the Prince Reference Library of the George C. Marshall Space Flight Center, Huntsville, Alabama. All National Aeronautic Space Administration centers will have immediate access to any information in the library through a television display or an electrostatic print-out of material requested. The system meets three important information retrieval requirements: (1) fast automatic access, (2) flexibility in updating, and (3) compression of stored data. A master file and a reference file are kept. The reference file is loaded on the video tape recorder in a ready position for immediate display or recording. Every document has a specific address that is recorded on an auxilliary track for immediate access.

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[1]Irving Abzug, "Graphic Data Processing," Datamation, Vol. 11 (January 1965), pp. 35-37.

Telephone long lines or microwaves can be used to connect the library to the many National Aeronatical Space Administration stations throughout the United States. Storage of more than two hundred and fifty thousand document pages can be kept on one fourteen inch reel of standard video tape.[1]

The utilization of a similar videofile system for educational purposes seems practical. Many schools have already invested in television display units for closed circuit teaching. With the inclusion of a computer to control the program, a vast amount of information could be made available to classes or individuals as the situation demands. The contents of the library could be updated and altered at will. This would require no special programming knowledge unless the computer control program was to be altered also. Many problems that a student faces in library research could be eliminated. There would be no waiting for books on call, time consuming trips to and from the library building, and time consuming process of copying pertinent material by hand.

The videofile system, as it exists today, has a specific application; however, there are other research findings that will have a similar impact on the educational field. L.H. Martin, president of Intectron Incorporated, Newton Lower Falls, Massachusetts, describes a "mechanized library" utilizing new photographic processes. The research on this project was supported by the Council of Library Resources and the

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[1]"The Videofile System," Datamation, Vol. 11 (January 1965), p. 57.

AVCO Corporation, Crosley Division, Electronic Research Laboratories, Boston, Massachusetts. The system utilizes special photographic plates called memory planes. Microphotographs are arranged in rows and columns on the plane with a reduction ratio of about 100:1. A typical memory plane may contain 10^4 document page images or an equivalent of forty, two hundred and fifty page books. The memory capacity of this particular unit can handle one hundred memory planes stored in a compact unit of about one cubic foot. The image selected can be projected on microfilm, displayed on a kinescope screen, or electrostatically printed or transmitted. A conceptual view of the system is shown in Figure 8, page 39. The time required from addressing of the information to display averages approximately one second.[1]

It is not difficult to conceive an entire university library being stored on a number of memory units. In most cases it would not be desirable to convert the entire library. Reference books, non-fiction books, and documents that are related to particular fields would be the items most suitable to include on the memory planes.

The student terminal is a very important part of the instructional system. This is the only part of the system with which the student comes in direct contact. The design should be carefully thought out. No one terminal could suit all the training needs in our public schools, industry, or

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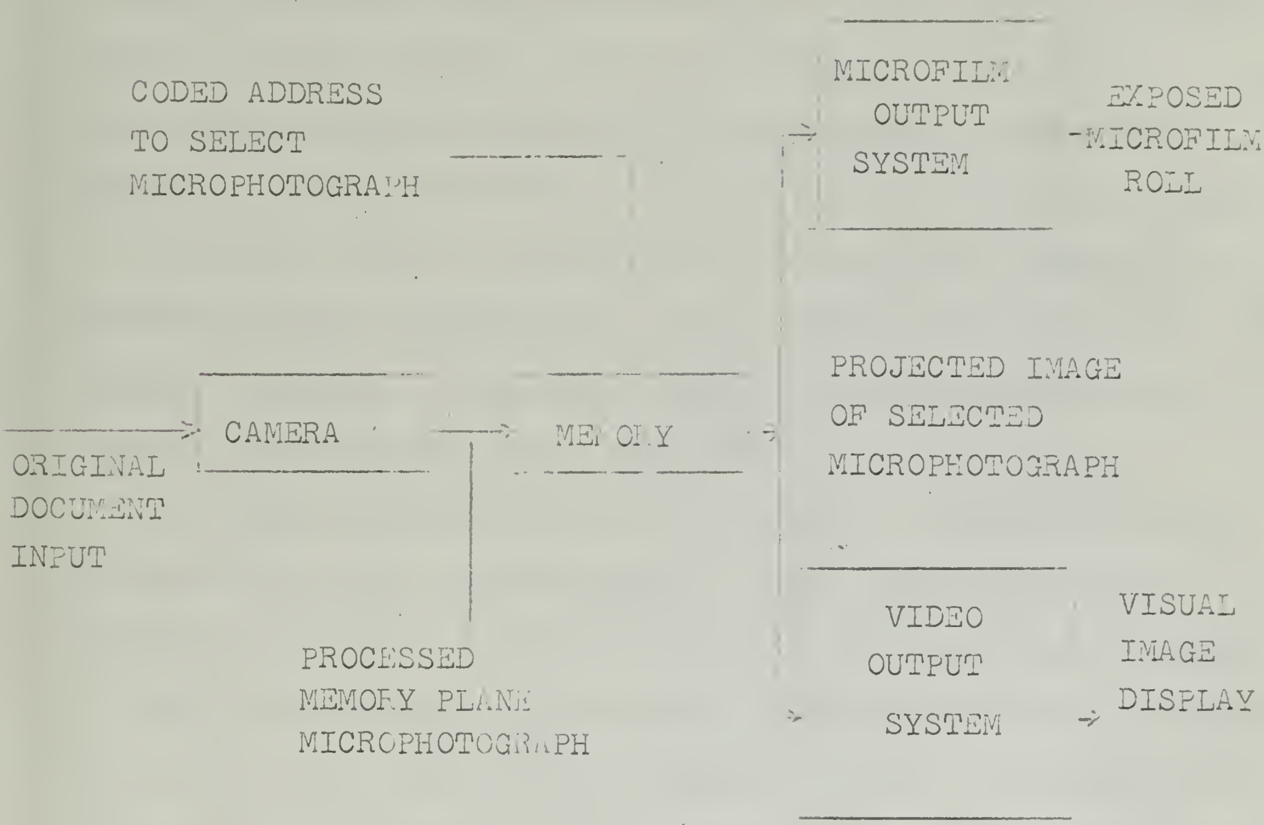
[1] L. H. Martin, "The Mechanized Library," Datamation, Vol. 10 (September 1964), pp. 32-36.

FIGURE 8

BASIC ELEMENTS OF A MECHANIZED LIBRARY[a]

Basic Elements of VERAC-903



[a] L. H. Martin, "The Mechanized Library," Datamation, Vol. 10 (September 1964) p. 33.

the military services. First grade students with certain physical limitations would require an entirely different terminal than a student of electronics, who is undergoing trouble shooting training at a military training school. Simplicity and ease of operation are musts if the display unit is to be kept from being detrimental to the learning process. Most of the research in computer-based instruction has been in the area of course content, program design, and the technical requirements of the computer and peripheral equipment. Most of the student terminals have incorporated a typewriter, commonly used with the computer; various video display units; and a number of selector button arrangements. The specific design of the student terminal, with student-machine relationships as a primary consideration, has been ignored in most cases.

A recent development by International Business Machines Corporation in the display console field shows that some intensive research is being conducted. Irving Abzug, manager of image processing at International Business Machines Corporation, describes a graphic data display device used with the 360 system.[1] It is designed primarily to help engineers, designers, and business men work with charts, curves, sketches, drawings, and messages. The main elements of the system are: (1) a system 360 processor, (2) the visual display console with light pen and vector graphics capability, (3) a 35mm film recorder, and (4) a 35mm film scanner. The scanner converts images to digital form for further processing or storage on discs, drums, or tapes.

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[1]Abzug, op. cit., pp. 35-37.

The student terminal consists of a twenty one inch cathode-ray tube and three manual input devices - the alpha-numeric keyboard, a program function keyboard, and a light pen. Images are generated by a computer program which positions and reflects the cathode-ray tube;s electron beam to any of the one thousand-twenty four by one thousand-twenty four addressable grid points on the twelve inch square display area. By proper combinations the display can produce lines, arcs, circles, or more complex geometric figures and an unlimited variety of graphic symbols.

An example of the flexibility of the display would be en electrical engineering student who wants a schematic of a circuit displayed. With the circuit displayed by soliciting through the alphanumeric keyboard and the program function keyboard, the student can assign various values to different circuit elements. The computer takes these values and produces the output wave form that represents the values assigned to the circuit. By varying the circuit values, the student can see a graphic display for every change of values. The same thing can be applied to the architectural student or one who is studying the use of blueprints. The display device can be utilized in many ways to give graphic and verbal display. Mr. Abzug states:

> Graphic data processing enables a user to become an integral part of a data processing complex. The new techniques allow direct man-machine exchange of graphic information, and make possible instantaneous intervention to provide an optimum combination of human judgement, computer speed, and accuracy.[1]

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[1]Ibid., pp. 35-37.

The field of student terminal design can be one of the most promising fields in computer-based instruction. Now that computer assisted teaching is shown to be feasible, the actual man-machine contact point, the display-response terminal, can receive a long intensive study.

Recent Experiments

Many major projects are in process at the present time to explore computer-student relationships. Some of these are summarized in Appendix A. Two significant experiments will be discussed here - an International Business Machines research project and project CLASS.

The International Business Machines research system will be discussed because it it based upon conversational interaction. This is the desire of most adaptive teaching systems. Project CLASS will be discussed as it has been developed to investigate computer applications in a total systems concept of education and training.

William R. Uttal designed and developed the International Business Machine's research system.[1] In 1963 the 1410 system consisted of a console, printer, Ramac, audio-ramac, buffered multiplexer and real time clock, card read-punch, steno terminal, typewriter teaching stations, and perceptual display. The computer had a 40,000 character magnetic cor array, while the disc unit had a capacity of ten million characters. Three courses can be taught simultaneously:

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[1]Werner J. Koppitz, "The Computer and Programmed Instruction," Datamation, Vol. 9 (November 1963), pp. 50-58.

stenotypy, German-reading, and statistics. The German and statistics courses were presented on the typewriter terminals. The computer printed the question, and the student responded by typing the answer. The computer checked the answer and immediately informed the student of the results. Although only ten terminals were connected for the research, the computer has the capacity to handle two hundred students without any perceptible waiting period. Textbooks were used with the courses, but they were expecially written to become integral parts with the programs.

The highest degree of adaptation came in the stenotypy course. The feedback from the student determined what was taught next, how often the item had to be repeated, and the speed of presentation. This type of computer-student interaction exemplifies the goal of individualized computer-based instruction.

Future plans for the German course consist of an error analysis that registers and analyzes student errors. It also classifies them and determines areas of weakness in which the student is urged to do some additional work.[1]

System Development Corporation began its experimentation with variable-sequence methods of automated teaching in 1959.[2] In 1960 a system was introduced to teach one student at a time, using a Bendix G-15 computer as the central unit. The program was fed into the computer by punched paper tape. The computer program controlled a random access 35mm slide

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[1] Ibid., pp. 50-58.

[2] John E. Coulson, "A Computer-Based Laboratory For Research and Development in Education," Coulson, op. cit. p. 191.

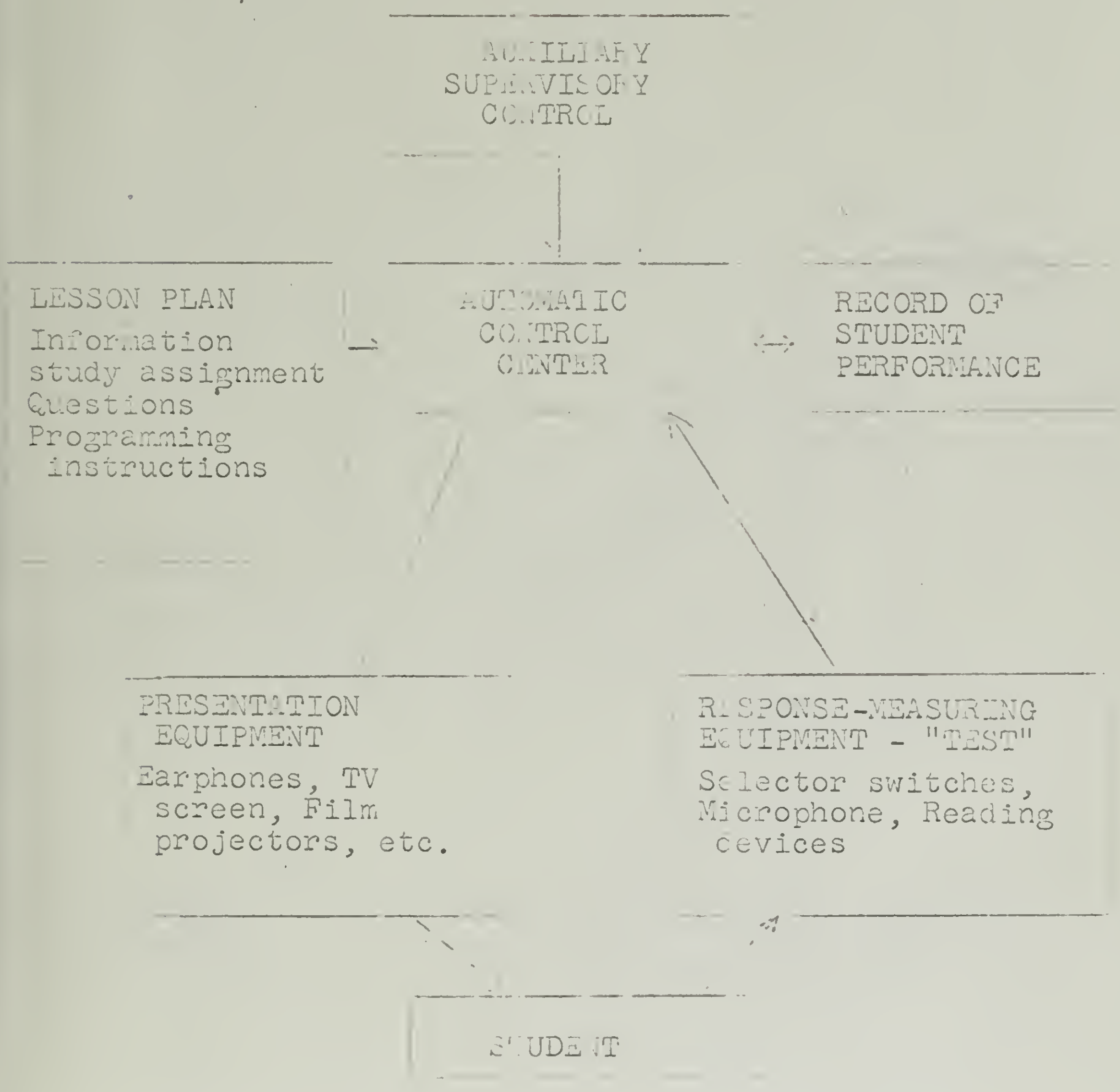
projector and an electric typewriter. The slide projector had a 600 slide capacity. Branching programs could be given with this system, with the student responding to multiple choice questions by striking appropriate keys on the typewriter. The student was informed of his success by the computer through messages typed on the typewriter. Short messages or instructions were typed on the typewriter. Longer ones could be presented on a slide. Findings from this experiment showed that branching methods were more efficient in instruction than fixed-sequence (linear) presentations.

Project CLASS was begun in September 1961. The word CLASS (Computer-based laboratory for automated school systems) suggests the concept that underlies the project. This concept or philosophy is that automated instruction, though of great significance to education, is but one elements of the entire educational complex.

Project CLASS consists of a functional area of four rooms. There are two large classrooms divided by a folding, sound-attenuating partition. Twenty students can be accommodated in the combined area. The other two rooms serve as a counselling area and an administrative area. Operationally the project consists of a Philco 2000 (large digital computer), a buffer designed by System Development Corporation engineers, individual and group display devices, and teaching stations. The project will provide opportunities to explore interactions of such instructional methods as lectures, films, television, computer-based instruction, and textbooks. The project is designed as a simulation laboratory where different educational

FIGURE 9

AUTOMATIC TEACHING DEVICE FOR INDIVIDUAL[a]



[a]P. K. Weimer, "A Proposed Automatic Teaching Device," Teaching Machines and Programmed Learning, ed. A. A. Lumsdaine and Robert Glaser (Washington, D. C. : National Education Association of the United States, 1960), p. 313.

configurations can be studied.

Besides controlling much of the course content the computer can take care of printing student reports, personality test results, current student performance, and other information that will assist the counselor in meeting the needs of the student.

Administratively, the computer can be used to prepare student class assignments, logistic functions, daily attendance, a variety of schedules, fiscal accounts, registration, bus scheduling, financial accounting, payrolls, and forecasting of enrollment trends for predictive purposes. The computer could also be programmed to train and evaluate administrative personnel.[1]

In order to visualize a computer controlled teaching situation, Figures 9 and 10 on pages 45 and 46 are shown.

If computers are to be utilized in our educational and training institutions, to what extent should they be used? What will be the cost of mass computer-based instruction? Many questions are to be examined in the next few years in order to properly evaluate automated education. The next chapter deals with the problems that will be encountered as this proposed system materializes in our society.

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[1]Ibid., pp. 191-203

CHAPTER IV

EMERGING EDUCATIONAL TECHNOLOGY

> Mr. X did, however, feel that for accelerated students who wanted to cover more ground or for the dull, slow student, programs might have some usefulness. He was unwilling to say that the whole idea of programing is unsound, and he did like the idea of feedback. But he certainly felt that programed materials would not be of any great use to him in teaching his regular classes.[1]

> It is my firm belief that this program is going to provide an important alternative to the type of training that is now given and should prove most valuable to the military services who are continually being called upon to train more people more things in less time.[2]

These two statements show the range of opinion that this new concept of education has developed in the few years in which teaching machines and programmed instruction have been used experimentally. The first statement reflects the views of a geometry teacher in Chicago who used programmed materials for one semester. The second statement comes from a research psychologist who is deeply involved in studying computer uses in military training for the Office of Naval Research.

A certain story describes the efforts of six blind men in describing an elephant. To the one who touched the tail, the elephant was a rope. Another man touched the leg and described the elephant as a tree, and so on.

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[1]Herbert Thelen and John R. Ginther, "Experiences With Programed Materials in the Chicago Area," Four Case Studies of Programed Instruction, Jack V. Edling et al. (New York: Fund for The Advancement of Education, 1964), p. 55.

[2]G. L. Bryan, op. cit., p. 8.

> An analogy can be made between the experiments being conducted on programmed instruction and the investigations of the elephant by the blind men. One person investigates here, another investigates there, yet the sum does not add up to a description of the strange phenomenon of learning. It is evident to anyone who has tried to organize an investigation on programmed learning that he touches only a limited area of the subject and then probably on the surface only.
>
> Why is this so? It certainly appears more desirable to step back and get a whole, or integrated, view of the teaching-learning process and then, knowing where each part fits into the whole, to examine the parts in detail. Possibly the reason that the total picture has eluded investigators is that they have not yet developed the perceptual means for viewing an extremely complex, multivariate dynamic domain. They look at only a limited range of a limited number of variables.[1]

It is not proposed to examine all the variables of the learning process. All the variables have not been defined, and an adequate examination of all variables would be far more extensive than this paper could encompass. The items examined are the changing role of the instructor in a computer-based instructional situation, the cost effectiveness of the proposal, the possible tie with the Navy manpower accounting systems, and various resistances to the needed change involved in incorporating such a system into the military or civilian training situation. After examining these items, a total systems concept is proposed as a feasible structure for a future training system.

Instructor's Role

The role of the instructor in the classroom of tomorrow can be different from that of the traditional classroom.

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[1]Arnold Roe, "Research in Programmed Learning," Coulson, op. cit., p. 113.

What will the differences be? Will an instructor even be required? Dr. Maurice W. Sullivan, former director of graduate studies in foreign languages at Hollins College, Roanoke has this to say about the teacher's role in tomorrow's classroom:

> I think we can program every subject there is. I would even go one step further. I think we could do without teachers. And I would go to a step beyond that. I think the school of the future will be in the home and not in public school buildings. A teacher might be available for supervision but the student with his machine in his home would be able to do the same kind of work that he can do in the classroom today.[1]

Mr. Sullivan has done away with the teacher and the school, so ther exists no suitable framework to evaluate the teacher's role. This view is not widely held, as it certainly is not reflective of the reality of the situation today. There are still schools, industrial training centers, and military training centers.

Dr. Benjamin Fine defends the teacher and his position by stating:

> Let us get one thing straight: the teaching machine will never fully replace the teacher. It is not a threat. Just as progressive education freed the child from a hostile stuffy climate, so the teaching machine will free the teacher from drudgery and routine work.[2]

The possibility of replacing teachers with teaching machines of any kind is very remote. The economic implications of hundreds of thousands of teachers unemployed would be enough to stymie any such effort. The developing character

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[1]Benjamin Fine, Teaching Machines (New York: Sterling Publishing Co. Inc., 1962), p. 106.

[2]Ibid. p. 109.

of a student is just as important, or more so, as the amount of knowledge he acquires in the learning process, and the teaching machine will not have the ability to interelate directly with the personality of a student in order to bring about proper character adjustment. Of course, the force of the instructor's personality will indirectly affect the student through the structure of the programmed material.

It can be assumed that an instructor will be present or accessible in a computer-controlled learning situation. His role might be changed slightly, in that he would be required to gain a mastery over the programmed material. An instructor needs to be aware of the inadequacies of the machine and be able to compensate for these. The instructor may need more training in counseling techniques, as his face to face encounters with the student will be on an individual basis more than on a group basis. The individual encounter may be necessary, as the student will be progressing at his own rate through the course material. Through careful scheduling of counseling sessions, it is conceivable that the student will feel he is getting more attention from the instructor in computer assisted instruction than he did in the traditional classroom.

The instructor's primary goals may be changed from those of imparting knowledge to those of motivation, emotional and social adjustment, and stimulation of creativity. Of course, teachers have always been concerned with all of these goals, but the main emphasis has usually been on seeing

that the course material was imparted to the student.

The instructor may have the pleasant suprise of being able to analyze a student's daily progress without going through the time consuming process of testing and grading of tests. The computer system contains daily progress of each student in a random access file. More time can be spent in evaluating the daily progress for use in guidance and counseling. In other words, the time consuming drill, testing, and grading of tests can be eliminated. Putting a student's daily progress in an accessible position is a factor that should not be dismissed lightly. Many times a student's problems are not analyzed until it is too late to bring about a proper adjustment. The failing of a course may result, and many times the student is discouraged to the point that he will drop out of school. The attrition rate in the public schools may be affected dramatically if the students' problems can be analyzed quickly and accurately.

Perhaps the teacher will learn more about the learning process as he becomes separated from participation to a position of observation. He will have many opportunities to adjust the variables in the learning process and to evaluate the effects. As in all technological advances the requirements of personnel preparation will become more exacting. The teacher must be better trained in order to fulfill his role effectively in computer-assisted instruction.

Cost Effectiveness

> ...of the seven basic teaching activities (development of thinking, imparting subject matter, developing creativity, developing skills, teaching socialization, encouraging physical development, and child care) probably only one can be provided almost entirely by teaching machines. Therefore, in presenting the economics of teaching machines, it must be considered that neither the teacher nor the other facilities of the classroom are replaced. Thus, whatever the cost of teaching machines, it must be added to the current cost of classroom instruction. Its value must be measured in terms of improvement of the end product rather than in terms of substitution for the current process.[1]

The teacher is not likely to be replaced. The school facilities will probably remain the same with some additions to accommodate a computer system. A number of studies have been made to establish the relative cost of a teaching machine situation. Two experiments are mentioned. One compares a one student automatic machine with a teacher. The other study approximates the cost of a computer-based system.

John Annett, a British educator, has compared an automatic machine costing 350 pounds to a teacher receiving a salary of 1,000 pounds.[2] Mr. Annett estimated that the machine could be utilized for a 2,000 hour year. This would mean that the machine could handle one student at a time for 2,000 hours. The human instructor could teach 1,200 hours but would have twenty pupils at a rate of 24,000 hours per year. The cost of the human instructor was slightly more than the

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[1]Huskey, op. cit., pp. 257-258.

[2]John Annett, "Teaching Machines in Industrial and Military training," Austwck, op. cit., p. 72.

machine, but evaluation of the machine instruction showed that the student covered the same material in half the time as with conventional instruction. Mr. Annett concluded that the machine was clearly more economical than the human instructor.

Dr. Glenn L. Bryan has done some preliminary studies to measure the cost of a computer controlled system.[1] One unique feature of the study indicates that the utilization of large computers with extensive time sharing capabilities will actually lower costs. Dr. Bryan states: "Current estimates indicate that such facilities could be made available at the running cost of about 25 cents per pupil hour. Experience has shown that software costs tend to equal hardware costs in many advanced military computer systems. However, even the cost of 50 cents per student per hour does not appear to be inordinate."[2]

An accurate cost effectiveness study may be very difficult to make. In a very limited situation, it is fairly easy to arrive at accurate figures; however, the fully integrated computer-based system which handles many administrative functions, budget functions, various scheduling functions, and many research and simulation functions may be very difficult to describe in terms of cost effectiveness.

It may be assumed that a computer-based system wil not

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[1]Bryan, op. cit., pp. 5-6.

[2]Ibid., pp. 5-6.

[illegible]

[illegible]

[illegible]

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[illegible]

replace personnel or fecilities; therefore, any reduction in educational costs will be derived from savings in time which a student can progress through the learning process. Also to be considered is the quality of the product that the system produces. This factor alone could justify the entire system.

Manpower Accounting

The United States Navy has developed an extensive computer-based manpower accounting system. The training records and qualifications of an individual could be integrated into this system. The records are already included to some extent; however, it is conceivable that the computer system controlling the training facilities could be connected to the manpower accounting system. The manpower accounting system could be updated automatically as a student progresses through a course of study. Personnel requirements could be met efficiently as the as the manpower accounting system controlled the input into the training system, and in turn, it was constantly advised as to the progress of each student during the training period.

Resistance to Change

Dr. Murray Tondow, Palo Alto, California, Unified School District, in talking about the progress of educational technology within our educational system, states: "Importance arises in training new teachers and preparing present teachers for traumatic changes."[1]

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[1]Ed Yasaki, "Educational Data Processing," Datamation, Vol. 9 (June 1963), p. 26.

Resistance to the changes demanded by a computer controlled educational system may come from two directions. The system may be actively opposed by the existing instructors and administrators. This condition may exist in the public school system more than in industry or the military. Industry and military training can be adjusted fairly easily on grounds of economical effects; however, the public school system contains a greater element of emotional involvement than does training in military schools. If the system is to be incorporated, there must be a skillful selling process preceeding it.

The second type of resistance may come from the institutions that train instructors. A teacher that is not properly trained in utilizing these new concepts of educational technology may form an inactive resistance. The teacher must be convinced of the worthiness of the system and be trained in the most effective utilization of the system. Again the military and industrial training situations can be controlled more easily that the public school system. If a totally integrated system is called for in industry or the military, instructor training would be instituted immediately. This quick reacting system is not found in the public schools. Therefore, the military services can provide the system through which educational research and development can be evaluated. Such a system would call for some rather extensive changes in the present situation. Industrial training may lead the way if the present trend of educational technology proves to be economically sound.

The Total Systems Concept

The computer-business relationship has passed through the fascination stage into the area of systems analysis and development. At first the computer was looked upon as a great time saving mechanism for tedious office tasks such as inventory control, accounting, billing, and many other related tasks. Gradually the computer began to be considered in a larger concept than a labor saving device. Computer applications began to affect management at the decision making level. Forecasts of future market conditions and project evaluations are two examples of the many areas of management decision making that have been affected by the computer. The emphasis today is to have a corporation plan its entire functional structure around computers. Military planners are approaching the computer field with a total systems concept in mind.

Educational institutions seem to be in the fascination stage with computers. Operationally, the computer is used in the field of administration on a limited basis. It could probably be said of most educational institutions that they have adapted the machine to some specific uses within the present structure of the organization. No educational institution has yet built its organization around the computer, so as to utilize its potential to the fullest. Maybe this concept is coming in the way that it developed in the business community.

To utilize the computer to its maxium potential in a

training institution demands reorganization of every function of the institution. Two main areas of reorganization are administration and academic curriculum. Under administration there is simulation, model building, and student evaluations. Under curriculum there is programmed learning, library facilities, and simulation.

The administrative organization must start with basic assumtions. The first assumption is that the school facilities will be primarily the same with some alterations for the computers and the student-teacher terminals. The second assumption is that the student body will not be structured into classes. Student progression will depend entirely upon the individual student. The third assumption is that the faculty will be well trained in computer applications.

Simulation and model building are very closely related. Model building might encompass budgeting, scheduling (student, bus routes, etc.), design and construction of new facilities, and other related functions. Simulation is used to train the present administrative personnel for decision making about actual internal problems. A total simulated educational system could be constructed, and by stating different values for the existing variables evaluations could be made to affect future decisions about the real organization. Trying different projects in a simulation laboratory before implementation could mean the savings of considerable resources and effort.

Student records and evaluations may be used far more

efficiently under this type of system than in a traditional training system. John F. Cogswell of System Development Corporation envisions a student personality model for each student that could be updated from many sources.[1] The model would include data on appraisal tests, records of past achievement, teacher's observations, parent's comments, student's statements, and various test data associated with academic endeavor.

The student record would give an excellent descriptive summarization that would be up-to-date for use in counseling situations, job applications, college applications, and billet assignments. The problem of assigning grades to a student's performance would be almost entirely eliminated. The time needed to complete the course would be the most significant item in evaluating over-all student performance. Besides the time factor the student's performance profile in every course would be automatically recorded as the student progressed.

The academic curriculum may have to be completely re-organized. The major portion of the academic material may be programmed for direct student-machine learning. The programmed learning situation would be monitored by well trained instructors who could alter the program so that the best possible results are obtained. The initial trial of most programmed material might show some weaknesses, but these could be worked out through the teacher monitoring device.

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[1]Ibid., p. 25.

All relevant material such as dictionaries, special reference books, and applicable research articles could be utilized in a computer controlled mechanized library. The instructor could assign individual research requiring the student to examine a number of specific sources. The student could analyze these sources at a student terminal through a special video display or ask for an edectrostatically printed copy to take home for further study.

Simulation can be an efficient and dynamic learning device for a student. An example of this simulation would be a student involved in electronics trouble shooting of a particular piece of equipment. The computer could duplicate the circuitry on a standard piece of equipment and could control the readings of various circuits so that the student would have to follow certain procedures to analyze the trouble correctly. Other examples would include business decision games, war strategy and tactics games, medical diagnosis, and chemical formulation.

One criteria a total systems concept must include is the provision for analysis and alteration of any function. One danger to avoid is the tendancy to adhere too tightly to a particular way of operation so that the system loses its flexibility and the ability to adapt to improved concepts.

Conclusions

After examining the historical foundation of programmed learning, the problems of programming, and the computer applications, a number of conclusions can be drawn.

The concepts of programmed learning and computer-based instruction are in the early developmental stages.

The exact role of the computer in the training situation has not been adequately defined.

Subject matter evaluation and educational programming provide some of the most perplexing and complex problems for psychologists and educational technologists.

Complex information systems have been developed for business and military applications, but these findings have not been conclusively applied to the training field.

The computer provides the answer to the problem of establishing a fully adaptive automated teaching system.

> Nor do teaching machines presently sold have a very bright future. In actual classroom use they can be more a hindrance than a help. If they survive at all it will be in the form of a computer that offer the necessary instructional and administrative conveniences.[1]

The question of whether or not our training institutions should automate will continue to be presented. The forcefulness of the presentation will depend extensively upon the research being conducted in our educational institutions today. If automation comes it will be because it is clearly the best way in which to educate our growing population.

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[1]John P. DeCecco, Educational Technology (New York: Holt, Rinehart and Winston Inc.), p. 433.

APPENDIX

SUMMARY OF COMPUTER
BASED INSTRUCTIONAL SYSTEMS

The four summaries included in the appendix have been taken from a paper produced by the International Business Machines Corporation in 1964.

Coordinated Science Laboratory
University of Illinois
Urbana, Illinois

Peter G. Braunfield

The PLATO project was begun in 1960 using the ILLIAC computer, which has since been replaced by a CDC 1604. Information is presented to the student through slides projected on the rear of a TV screen. The student makes his response by typing his answer at a keyboard; this answer is displayed on the TV screen by a storage tube system, soon to be replaced by a special plasma discharge display tube. In addition to the "typewriter" portion of the special keyboard, there are several logic keys to allow the student to continue in the course, display preceding material, erase an answer, ask for a help sequence, etc. A special PLATO compiler has been prepared so that non-computer oriented researchers can prepare teaching logics with only a knowledge of FORTRAN.

Braunfield, P. G. Problems and prospects of teaching with a computer. J. educ. Psychol., 1964, 55, 201-211.

PLATO II and III. Digital Computer Newsletter, 1964, Vol. 16, No. 3, 14-17.

Training Research Laboratory
Bureau of Educational Research
University of Illinois
Urbana, Illinois

Lawrence M. Stolurow

Dr. Stolurow was originally associated with the PLATO project, but he is now director of a new project called SOCRATES (System for Organizing Content to Review And Teach Educational Subjects). The display unit for SOCRATES is a rear view projection screen on which is projected an image from a 35mm film strip. The student makes his response by pressing one of ten buttons and is immediately informed as to whether he is correct or incorrect by colored lights. Other terminal devices that can be used with the IBM 1620 include Autotutors, Percepto-Scope teaching machines, andIDIOT (the Illinois Device for Independent Operation and Teaching). A typewriter also could be used. Fourteen terminals re serviced by the central computer.

Stolurow, L. M. and Davis, D. J. Teaching Machines and computer Based Systems. Training Research Laboratory Tech. Rep. No. 1, August 1963.

Systems Development Corporation
2500 Colorado Avenue
Santa Monica, California

Dr. John E. Coulson

CLASS (Computer-based Laboratory for Automated School Systems) is part of a large, general purpose systems simulation research laboratory using a Philco S-2000. CLASS permits simultaneous instruction of twenty students, either individualized or in a group mode mediated by the teacher or computer. The instructional sequence is displayed to the student by a large capacity random access slide projector under computer control. The student responds to these multiple choice questions by pressing appropriate keys on a special student keyboard. Additional keys on the response device can be used to convey various types of information to the computer or teacher. Lights on the keyboard can be used to inform the student about the correctness of his response.

Bushnell, D. D. The Role of the Computer in Future Instructional Systems. Audio Visual Communications Review, 1963, 11, Supplement 7.

Bolt, Beranek, and Newman, Inc.
15 Moulton Street
Cambridge 38, Massachusetts

Dr. John A. Swets

The experimental computer teaching effort at Bolt, Beranek, and Newman has investigated a variety of applications of computers to the instructional process. Dr. J. C. R. Licklider, who is now on the staff of the Director of Research, IBM, was responsible for most of the development there before joining IBM. The Tutor 1 system investigated the teaching of German with computer controlled typewriters, and the Graph Equation system was concerned with complex displays for teaching mathematics. Their current efforts involve teaching medical diagnosis on a PDP-1 with both student input and computer display through a typewriter. Special routines have been developed that appear to be rather specific to the general problem area now under investigation.

Swets, J. A., Feurzeig, W., Harris, J. R., and Marill, T. The Socrates System: A Computer System to Aid in Teaching Complex Concepts. AMRL Memorandum P-43, June 1963.

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